Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 7 Number 2 May 2008 pp. 106 -113
ISSN 1119-7455

EFFECT OF COWPEA PLANTING DENSITY ON GROWTH, YIELD AND PRODUCTIVITY OF COMPONENT CROPS IN COWPEA/CASSAVA INTERCROPPING SYSTEM

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ABSTRACT

Field trials were conducted at the research farm of the National Root Crops Research Institute (NRCRI), Umudike (07° 33′ E, 05° 29′ N) in 2004/2005 and 2005/2006 cropping seasons to determine the effect of cowpea planting density on growth, yield and productivity of component crops in cowpea/cassava intercropping system. Cassava at a density of 10,000 plants per hectare was intercropped with cowpea at four planting densities (20,000; 40,000; 60,000 and 80,000 plants per hectare). Both crops were also planted in monoculture and in intercrop. The experiment was arranged in a randomized complete block design (RCBD) with three replications. The leaf area index (LAI) of cassava was highest with the highest cowpea planting density in 2005/2006, but in 2004/2005 cropping season both cropping system and planting density did not influence the LAI of cowpea. Cowpea LAI was similar in the 2 seasons with the highest planting density (80,000 plants/ha) producing the highest LAI. Similarly, fresh root yield (t/ha) of cassava was influenced by cropping system and population density in 2005/2006, but not in 2004/2005 cropping season. Cassava tuber yield was highest with the cowpea planting density of 80,000 plants/ha. Cowpea grain yield (kg/ha) was not significantly (P>0.05) affected by intercropping in the two cropping season. Grain yield of cowpea was highest with the highest cowpea density in 2005/2006 but in 2004/2005 season, there was no cowpea density effect. The relative yield total, expressed as land equivalent ratio of the two crops was greater than 1.0 in all intercrops. At the prevailing market price level (₦7.50 per kg for cassava and ₦ 33 per kg for cowpea), cassava intercropped with 80,000 cowpea plants/ha gave a higher monetary returns than when intercropped with other population densities of cowpea or in monoculture of the two crops. Similarly, cowpea at highest population density gave the highest monetary returns.

Key words: Cassava, grain cowpea, planting density, growth, productivity, intercropping.

INTRODCUTION

In the humid and sub-humid tropics, intercropping is almost synonymous with peasant agriculture to the extent that attempts to introduce sole cropping systems alien to the environment and tradition of the people have failed (Okigbo and Greenland, 1976; Ikeorgu *et. al.*, 1984). The advantages associated with this system are well documented (Odurukwe *et al.*, 1996; Muoneke and Asiegbu, 1997; and Kantor, 1999). Cassava (*Manihot esculenta* Crantz) is an important root crop often found in mixture with other subsistence staples, providing food and income for over 700 million people in the tropics (FAO, 1999). Although the cultivation of cassava by resource poor farmers in Nigeria has increased tremendously in recent years due to its adaptation to shorter fallow periods, relative drought tolerance, ability to thrive well in soils of low fertility and its storage potentials in the soil (Aduramigba and Tijani-Eniola, 2001; Olojede, 2004), it impoverishes the soil rapidly, unless the absorbed or lost nutrients are replenished (Ekanayake *et al.*, 1997; Eke-Okoro *et al.*, 1999). Asher *et al.*, (1980) reported that at a tuberous root yield of 30 t/ha the amount of major nutrient removed from the soil at harvest were 164 kg/N/ha, 31kg P/ha and 200 kg K/ha. Low soil fertility occurs in many cassava growing areas because the fallow periods have become shortened as the pressure on arable land is increasing. This has made the use of inorganic fertilizer necessary. But most farmers do not have access to inorganic fertilizer because of its high cost, inadequate supply and distribution problems. The direct use of soil amendments in cassava production is low and consequently the yield potentials of various improved varieties of cassava are not often attained. Leguminous plants currently present very good opportunity in sustainable maintenance of soil fertility. Of the various leguminous crops, cowpea appears to be one of the most important crops in playing this role (IITA, 1990). It is estimated that cowpea supplies about 40% of the daily protein requirements to most of the people in Nigeria (Muleba *et al.*, 1997). Cowpea can fix up to 88 kg N/ha (Fatokun *et. al.,* 2002) and in an effective cowpea-rhizobium symbiosis, more than 155 kg N/ha is fixed which can supply 80-90% of plants total N requirement. According to Ikeorgu and Odurukwe (1990), the performance of cassava/maize/legume association is dependent upon the population of the legume and they suggested that there is need to determine the optimum population density of these legumes in cassava based intercropping systems. Most agronomic research works had been on cowpea intercropping with cereals but few with root/tuber crops. Not much has been done on grain cowpea in the humid rainforest zone of southern Nigeria because of the pests and disease problems and low insolation prevalent in the area. The objectives of this study were to assess the yield and productivity of cassava and cowpea intercropping systems, and to determine optimum population of cowpea for effective cropping of cassava/cowpea.

MATERIALS AND METHODS

The experiment was carried out in two cropping seasons (2004/2005 and 2005/2006) at research farms of National Root Crops Research Institute (NRCRI), Umudike located on longitude 07° 33′ E and latitude 05° 29′ N. The soil was a sandy loam with acidic reaction which characteristics were as follows: Soil pH 5.20 and 4.90 (1:2.5 soil: water), organic carbon 0.81 and 1.24%, total N 0.14 and 0.16%, available P 30.0 and 28.3 cmol/K, exchangeable K 0.16 and 0.14 cmol/kg for 2004/2005 and 2005/2006 experiments, respectively. Annual rainfall ranges between 1800 mm and 2200 mm, annual average air temperature varied from the minimum of 22° C to maximum of 32° C; relative humidity ranged from 51% to 87% and sunshine hours from 2.69 to 7.86 hours per day. The monthly climatological data on rainfall, minimum and maximum air temperatures, relative humidity and sunshine hours were collected during the study periods (Table 1). Cassava and cowpea were planted the same day on 24 July, 2004 and 28 July, 2005. Cassava cuttings of about 25 cm long with at least five nodes were planted on the crest of the ridge at 1 m x 1 m giving 10,000 plants ha^{-1}. Four grain cowpea planting densities (20,000; 40,000; 60,000 and 80,000 plants ha^{-1}) were intercropped between rows of 10,000 cassava plants ha^{-1}). The cowpea populations were obtained with intra row spacings of 0.50, 0.25, 0.16 and 0.12m at one plant per stand and at constant inter-row spacing of 1 m. With the incorporation of four sole cowpea densities and one sole cassava density, the nine treatments were as follows: 20,000 sole cowpea plant ha^{-1}, 40,000 sole cowpea plants ha^{-1}, 60,000 sole cowpea plants ha^{-1}, 80,000 sole cowpea plants ha^{-1}, 20,000 cowpea plant ha^{-1} + 10,000 cassava plants ha^{-1}, 40,000 cowpea plants ha^{-1} + 10,000 cassava plants ha^{-1}, 60,000 cowpea plants ha^{-1} + 10,000 cassava plants ha^{-1} and 80,000 cowpea plants ha^{-1} + 10,000 cassava plants ha^{-1}. The plot size was 6 m x 6 m (36 m^2) each containing six ridges. The cowpea variety used was IT93K-452-1 and cassava variety was NR8082 in both cropping seasons. The cowpea variety used was erect and it matures within 3 months after planting. The cassava variety used was the branching type and matures for harvest within 12 months.

The treatments were arranged in randomized complete block design with three replicates. The crops received 400kg NPK (20: 10: 10)/ha^{-1} 21 days after planting (DAP). A second application of the same fertilizer mixture at 200 kg/ha was applied to the cassava crop 4 months after planting (MAP) to boost the fertility of the soil in both cropping seasons. At 14, 28 and 42 DAP, the cowpea was sprayed with cymbush at 800 g a.i ha $^{-1}$ against cowpea aphids, leaf hoppers, foliage beetles and flower thrips. Data on establishment percentage, plant height, leaf area index (LAI), grain yield (cowpea) and tuber yield (cassava), number of nodules and nodule weight (cowpea) were taken from three plants of each crop randomly from three inner rows at different growth stages and at harvest. The leaf area of both crops were determined by using core borer/punch method according to Adelana, (1980) and was estimated as leaf dry weight multiplied by disk area divided by disk dry weight. That is, leaf area = (leaf dry wt. x disk area)/disk dry wt. The leaf areas of the crops were then converted to their leaf area indices. Data on yield components of each crops were taken from 16m^2 (4m x 4m of inter and intra- row) from the inner rows. The data were analysed according to the procedure of a randomized complete block design and the treatment means were compared using standard error of the difference between two treatment means as outlined by Steele and Torrie (1980). Genstat Release 4.23 Discovery Edition statistical software package was used for the statistical analysis of the data.

Table 1: Weather records for the site of the experiments in 2004, 2005 and 2006

	Jan	Feb	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
2004												
Total rainfall (mm)	0.2	11.9	22.4	134.5	217.6	279.4	309.5	309.5	324.9	249.1	52.5	5.1
Maximum temperature (°C)	33	35	36	32	32	30	29	29	30	31	33	33
Minimum. temperature (°C)	21	23	24	24	22	23	22	22	22	23	22	21
Relative humidity (%)	63	65	66	78	79	83	85	87	85	82	81	80
Sunshine (hr)	2.4	4.8	4.0	4.6	5.7	3.9	3.6	1.7	3.2	5.3	4.8	5.6
2005												
Total rainfall (mm)	17.3	126.7	64.0	141.3	222.4	264.4	297.0	225.0	339.7	323.7	45.4	8.6
Maxi mum temperature (°C)	33	35	34	30	29	30	29	20	30	33	33	32
Minimum. temperature (°C)	20	23	23	24	23	23	23	22	23	22	23	21
Relative humidity (%)	53	79	78	77	81	90	88	85	86	84	82	79
Sunshine (hr)	4.5	50	4.4	4.8	5.8	3.7	3.1	3.4	2.0	5.2	4.9	5.3
2006												
Total rainfall (mm)	76.6	81.9	131.9	136.0	202.8	237.3	303.4	133.7	483.1	237.4	14.2	0.0
Maximum temperature (°C)	33	33	34	33	31	31	30	29	29	31	32	32
Minimum. temperature (°C)	24	24	24	24	23	22	23	22	22	22	23	20
Relative humidity (%)	81	80	80	79	83	84	87	84	86	84	82	70
Sunshine (hr)	5.7	6.0	5.7	6.6	4.8	5.2	3.0	2.7	2.4	4.5	5.5	6.4

Source: National Root Crops Research Institute, Umudike Meteorological Unit.

RESULTS AND DISCUSSION

Plant establishment and growth.

Establishment of cassava was significantly ($P<0.05$) higher in sole cropped cassava than in intercropped cassava in both cropping seasons (Table 2). The two higher cowpea densities (60,000 and 80,000 plants ha^{-1}) had higher establishment than the lower densities. The reduction of establishment percentage in intercropping could be due to the modification of the soil micro-environment at full coverage of cowpea at 8 weeks after planting as reported by Ikeorgu *et. al.*, (1984) in cassava/egusi melon intercropping system. Osiru and Ezumah (1994) have reported high variability in cassava with respect to sprouting ability and leafiness which they reported as a major factor in compatibility of cassava for intercropping with short duration crops. There was no significant effect of cowpea planting density nor intercropping on cassava plant height and leaf area index in both cropping seasons (2004/2005 and 2005/2006) (Table 2), but cowpea density significantly ($P<0.05$) increased LAI in 2005/2006. One expected plant height to increase with cowpea population density as a result of crowding and competition for light but this result did not conform to this expectation, probably because the cowpea population at which interspecific competition for light becomes limiting might not have been reached. Besides, the growth habits of the two crop species differed; while cowpea was low growing, cassava has erect growth. This result also showed cassava plant height, number of branches and LAI increased with age. Similar results had been reported by Olasantan (1993) in cowpea/cassava and Aduramigba and Tijani-Eniola (2001) in groundnut/cassava intercropping.

Table 2: Growth and development parameters of cassava as influenced by cowpea population in 2004/2005 and 2005/20 cropping seasons

Cropping	Stem establishment (%)		Plant height (cm)						Leaf area index (LAI)					
	2004/ 2005	2005/2006	2004/2005 Weeks after Planting			2005/2006 Weeks after planting			2004/2005Weeks after Planting			2005/2006 Weeks after planting		
			3	6	12	3	6	12	3	6	12	3	6	12
Sole cassava	98.1	93.3	129.3	156.2	155.3	92.4	155.6	162.4	0.12	0.41	0.7 3	0.26	0.64	0. [cut off]
Intercropped cassava	89.1	81.4	114.3	142.7	164.6	106.9	159.9	166.2	0.11	0.46	0.6 8	0.25	0.66	0. [cut off]
SED	3.14	5.38	8.47	10.03	12.44	9.62	12.74	12.51	0.04	0.21	0.1 7	0.02	0.05	0. [cut off]
Significance	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N [cut off]
Cowpea population Density (Plants/ha)														
20,000	89.8	77.5	120.7	148.9	171.4	112.2	164.3	169.6	0.14	0.43	0.56	0.23	0.75	0. [cut off]
40,000	83.3	74.4	109.7	134.9	149.2	107.1	161.8	166.9	0.08	0.70	0.72	0.25	0.56	0. [cut off]
60,000	92.6	84.0	105.8	137.3	159.9	112.8	166.2	172.7	0.12	0.31	0.77	0.26	0.64	0. [cut off]
80,000	90.74	89.8	121.1	149.6	178.0	95.4	147.4	155.7	0.11	0.39	0.66	0.28	0.67	0. [cut off]
SED	3.10	5.30	10.61	13.31	14.81	12.46	17.39	17.41	0.05	0.23	0.23	0.02	0.03	0. [cut off]
Significance	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	*	*

Significant (P < 0.05) ; NS = not significant (P > 0.05).
SED = Standard error of difference between any two treatment means.

Table 3: Growth and development parameters of cowpea as influenced by cowpea population and cassava in 2004/2005 and 2005/2006 cropping season

Cropping	Germination (%)		Days to 50% Flowering		Vine length (cm)				Leaf area index (LAI)			
	2004/ 2005	2005/ 2006	2004/ 2005	2005/ 2006	2004/ 2005		2005/ 2006		2004/2005		2005/2005	
					8 (WAP)	10 (WAP)	8 (WAP)	10 (WAP)	8 (WAP)	10 (WAP)	8 (WAP)	10 (WAP) [cut off]
Sole	73.8	69.5	41.00	46.83	159.6	163.6	135.3	146.0	0.70	0.74	0.88	1. [cut off]
Intercrop	80.7	70.8	41.58	46.58	152.4	156.3	134.1	145.4	0.84	0.86	0.81	1. [cut off]
SED	5.20	4.20	0.39	0.52	8.68	8.54	3.64	3.66	0.13	0.13	0.17	0. [cut off]
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N [cut off]
Population Density (pt/ha)												
20,000	75.5	69.0	41.67	46.83	169.6	172.7	133.1	143.8	0.43	0.44	0.37	0. [cut off]
40,000	89.6	68.6	41.33	46.50	166.7	170.3	132.4	142.2	0.64	0.67	0.68	0. [cut off]
60,000	72.8	76.7	41.50	47.00	139.8	144.4	128.8	140.3	1.03	1.07	0.95	1. [cut off]
80,000	71.3	66.1	40.67	46.50	148.0	152.4	144.6	166.5	0.97	1.03	1.38	1. [cut off]
SED	6.48	5.69	0.56	0.77	10.19	10.24	3.76	3.44	0.11	0.11	0.09	0. [cut off]
Significance	*	NS	NS	NS	*	*	*	**	**	**	**	**

*, ** = Significant (P < 0.05, 0.01) respectively; NS = Not significant (P > 0.05).
SED = Standard error of difference between any two treatment means.

Table 4: Yield and yield components of Cassava in 2004/2005 and 2005/2006 cropping seasons

	No. of tubers/plt.		No. of marketable tubers/ha		No. of unmarketable tubers/ha		Tuber yield (t/ha)	
Cropping season	**2004/2005**	**2005/2006**	**2004/2005**	**2005/2006**	**2004/2005**	**2005/2006**	**2004/2005**	**2005/2006**
Sole	7.72	12.53	57.70	92.30	35.0	58.0	46.90	32.0
Intercrop	6.97	14.17	52.70	80.70	30.90	89.20	41.00	37.80
SED	1.40	1.82	12.42	8.01	**7.22**	**21.30**	**6.03**	**1.25**
Significance	NS	NS	NS	NS	NS	NS	NS	*
Cowpea density								
20,000	7.86	12.86	54.30	79.30	40.00	75.00	45.90	36.84
40,000	5.56	15.83	41.70	78.00	25.00	112.00	36.43	37.39
60,000	6.42	14.00	51.30	81.00	33.00	87.00	39.37	36.30
80,000	8.06	13.97	63.70	84.7	6.21	83.00	43.83	40.67
SED	1.81	2.48	16.67	11.62	8.79	28.40	8.47	0.97
Significance	NS	NS	NS	NS	NS	NS	NS	*

* = Significant (P < 0.05) ; NS = Not significant (P > 0.05).
SED = Standard error of difference between any two treatment means.

Table 5: Yield and yield components of cowpea in 2004/2005 and 2005/2006 cropping season

	Number of Nodules/plt.		Nodule wt. (g/plant)		No. of seeds/ pod		Pod length (cm)		100 seed wt (g)		Grain yield (kg/ha)	
Cropping season	**2004/ 2005**	**2005/ 2006**	**2004/ 2005**	**2005/ 2006**	**2004/ 2005**	**2005/ 2006**	**2004/ 2005**	**2005/ 2006**	**2004/ 2005**	**2005/ 2006**	**2004/ 2005**	**20004/ 2005**
Sole	12.94	17.88	2.47	3.03	7.48	12.35	9.57	13.59	16.75	20.09	773	426
Intercrop	9.89	15.00	1.92	2.27	7.85	12.20	9.58	12.52	17.08	20.18	582	420
SED	0.69	1.36	0.14	0.36	0.52	0.40	0.30	0.51	0.80	0.30	115.7	67.5
Significance	*	*	*	*	NS	NS	NS	*	NS	NS	NS	NS
Population density												
20,000	12.55	13.89	2.43	1.79	7.87	11.93	9.49	12.61	16.33	20.57	674	289
40,000	11.50	14.87	2.08	2.74	7.83	7.83	12.77	9.97	12.82	16.83	894	345
60,000	11.33	17.20	2.56	2.58	7.67	12.23	9.57	12.96	17.50	19.88	472	524
80,000	10.28	19.82	2.01	3.51	7.30	12.17	9.27	13.81	17.00	20.30	672	532
SED	1.35	1.65	0.26	0.43	0.77	0.56	0.41	0.78	1.17	0.40	154.5	70.8
Significance	NS	*	NS	*	NS	NS	NS	NS	NS	NS	NS	*

• Significant (P < 0.05) ; NS = Not significant (P > 0.05). SED = Standard error of difference between any two treatment means.

Table 6: Land equivalent ratio (LER) in cassava/cowpea as influenced by cowpea population density

	2004/2005			**2005/2006**		
Cowpea density (plants/ha)	**Partial LER**		**Total LER**	**Partial LER**		**Total LER**
	Cowpea	**Cassava**		**Cowpea**	**Cassava**	
20,000 + cassava	0.85	1.21	2.06	0.92	1.15	**2.07**
40,000 + "	0.89	0.87	1.76	0.86	1.18	**2.04**
60,000 + "	1.04	1.10	2.14	0.98	1.14	**2.12**
80,000 + "	0.93	1.24	2.17	0.97	1.27	**2.24**

Table 7: Monetary returns of crop yields (₦/ha x 10^3) in cassava/cowpea intercropping as influenced by cowpea population density in 2004/2005 and 2005/2006 cropping seasons

	2004/2005			2005/2006		
	Partial		Total	Partial		Total
Cowpea density (plants/ha)	Cowpea	Cassava		Cowpea	Cassava	
20,000 sole	37.3	-	37.3	14.4	-	14.4
40,000 sole	47.4	-	47.4	17.1	-	17.1
60,000 sole	23.5	-	23.5	24.5	-	24.5
80,000 sole	33.6	-	33.6	30.32	-	30.32
Cassava sole	-	234.6	234.6	-	192.0	192.0
20,000 + cassava	24.5	217.7	242.2	13.2	221.0	234.2
40,000 + "	34.7	180.2	214.9	14.7	225.3	240.0
60,000 + "	19.7	196.7	216.4	23.6	217.8	241.4
80,000 + "	28.0	224.2	252.2	26.6	244.1	270.7

Cowpea was costed at ₦45.87/kg and cassava @ ₦6.00/kg, the prevailing market prices at the time of harvest.

There was no effect of intercropping on cowpea seed germination, vine length, days to 50% flowering and leaf area index in both cropping seasons (Table 3). Cowpea vines at 20,000 and 40,000 plants ha^{-1} were longer than at 60,000 and 80,000 plant ha^{-1} in 2004/2005 but in 2005/2006 the vines was longer with the highest cowpea density at 8 and 10 weeks after planting (WAP). This may be attributed to the reduced competition for edaphic factor at the lower densities (Ikeorgu *et. al.*, 1984; Eke-Okoro *et. al.*, 1999). There was no effect of cowpea planting density nor intercropping on days to 50% flowering. This was in contrast to the earlier report by Rhoda (1989) that increasing planting densities could delay flower formation in legumes. The flowering habit of cowpea may be genetically rather than environmentally controlled. The cowpea leaf area index (LAI) was highest with the two highest cowpea planting densities in 2005/2006 and 2004/2005 cropping seasons. The higher LAI with highest cowpea densities, especially at 8 and 10 WAP was due to more leaf cover than the lower planting densities.

Yield and yield components.

The effects of cropping system and cowpea population density on number and weight of marketable and unmarketable roots as well as total number of roots ha^{-1} in 2004/2005 and 2005/2006 cropping seasons were not significant (P>0.05) (Table 4). In 2005/2006 cropping season, tuber yield was higher in intercropping than in sole cassava crop probably as a result of use of additional nitrogen contributed by cowpea in the intercropping system. Also, cassava tuber yield increased with increase in cowpea planting density in 2005/2006 as a result of incremental contribution of nitrogen by high population of cowpea. The highest tuber yield was obtained at 80,000 in 2005/2006 (Table 4). Increases in cassava root yield with increased cowpea population density had been reported (Eke-Okoro *et. al.*, 1999; Jagtap *et. al.*, 1998). The wide maturity gap between cowpea (about 90 days) and cassava (about 360 days) and the slow initial growth of cassava enhanced the compatibility of cassava and cowpea as intercrops (Muleba *et. al.*, 1997; Ikeorgu and Odurukwe, 1990; Udealor and Asiegbu, (2005). Because cowpea is a legume and therefore fixes nitrogen, cassava benefits from the residual nitrogen fixed by cowpea as well as organic matter added by cowpea residues after its harvest. Results of cowpea/cassava intercropping trials in South America (CIAT, 1993) contradicted the above results as cowpea depressed cassava yields by up to 30% depending on the growth habits and vegetative development of the crops.

Sole cropped cowpea produced more and heavier nodules per plant than intercropped cowpea in both cropping seasons (Table 5). Means number of nodules produced in 2004/2005 and 2005/2006 by sole cropped cowpea were 12.94 and 17.88/plant respectively, while number of nodules in intercropped cowpea were 9.89 in 2004/2005 and 15.00/plant in 2005/2006. Nodules weight per plant followed the same trend as number of nodules per plant. Mean nodule weights for sole and inter cropped cowpea were 2.47 and 1.92g/plant in 2004/2005 and 3.03g/plant and 2.29g/plant in 2005/2006, respectively. Cowpea planting density did not affect cassava yield in both seasons.

Intercropping reduced the number of nodules and weight of nodules in both croppings and pod length in 2005/2006 but did not affect seed/ pod, 100 seed weight and grain yield (Table 5). The number of nodules, nodule weight per plant and grain yield increased with cowpea planting density in 2005/2006 while these were not affected by cowpea planting in 2004/2005. In 2004/2005 season, cowpea grain yield was increased by 33% with increase in cowpea planting density up to 40,000 plants ha^{-1} and by 19, 81 and 84% with 40,000; 60,000 and 80,000 plants ha^{-1} in 2005/2006. Yield reduction was more in cowpea than in cassava, probably due to rodents attack on cowpea and also due to flooding that resulted and smothered cowpea and reduced its population, especially in 2004/2005 cropping season thus resulting in lower yield of cowpea in that year than in subsequent year. Excessive rainfall causes poor performance of legume, (Ramakrishna *et. al.*, 1992). In 2004 and 2005 the total amount of rainfall were 1911.4mm and 2075.5mm respectively (Table 1).

The productivity of the mixtures:
Intercropping resulted in yield advantages in both cropping seasons; the total land equivalent ratio (LER) was between 1.76 and 2.17 (2004/2005) and between 2.04 and 2.24 (2005/2006) thus showing higher productivity of between 26% and 117% (2004/2005) and 104% and 124% (2005/2006) due to intercropping (Table 6). In 2004/2005 and 2005/2006 cropping seasons, these yield advantages were highest with intercropping at 80,000 cowpea plants ha^{-1} (117% and 224%, respectively). The partial LER of the component crops showed that cassava always contributed more to the total yield than cowpea, except in 2004/2005 cropping season when intercropping with 40,000 cowpea plants ha^{-1} had more partial LER (0.89) than cassava (0.87). The higher partial LER of cassava, at almost all cowpea densities indicated that cassava was more competitive than cowpea and that cassava utilized the N fixed by cowpea for better growth and yield.

For each cowpea planting density in 2004/2005 and 2005/2006 cropping seasons, the partial monetary returns were always higher in sole than in intercropping (Table 7). In cassava, monetary return was higher with sole crop in 2004/2005 whereas in 2005/2006, monetary returns were higher in intercropped than in sole cassava. Among the intercropped cassava, monetary return was highest with cassava intercropped with the highest cowpea planting density. The total monetary return was highest when cassava was intercropped with the highest cowpea density (80,000 plants ha^{-1}) in both seasons indicating highest income to the farmer at that intercropping system. The high total monetary return in intercropping was contributed considerably by the cassava component as depicted by its higher partial monetary returns and land equivalent ratio due mainly to its higher output than cowpea. Ogbuehi and Orzolek (1987) had reported that intercropping where land is scarce would always generate a higher gross monetary return per unit area of land compared to sole cropping but Ifenkwe and Odurukwe (1990) and Kumar and Yusuf (1991) observed that the highest LER would not always reflect the highest monetary return to the farmer.

The work reported here did not take into account additional yield of cowpea hay, an important product in a ruminant livestock based farming system where it is even as important as grain yield. Inclusion of this might raise both LER and gross return and thus further improve the productivity of the cropping system. Based on both the LER and gross monetary returns of the system, cassava/cowpea intercropping, at 80,000 cowpea plant ha^{-1} seemed to be the most productive with the highest income to the farmer, and is recommended over sole cropping system. The cassava crop benefits from the residual nitrogen fixed by the cowpea. The two crops are compatible as their growth stages for competition for growth factors do not overlap.

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